

A METHOD AND ARRANGEMENT FOR REDUCING CYCLO-STATIONARY CROSS-TALK NOISE

Field of the invention

5 The present invention relates to a method and arrangement for reducing cyclo-stationary cross-talk noise and more particularly to mitigate the effects of cyclo-stationary cross-talk noise from narrow band time divided duplex systems into a wide band transmission system within a copper wire-pair transmission network. The wide band transmission system utilises frequency division duplex and
10 the frequency band is divided into pairs of frequency bands having opposite transmission directions. The transmission directions of the frequency bands are switched in synchronism with the cyclo-stationary cross-talk noise from the time divided duplex systems.

15 State of the art

In certain copper access networks there exist narrow band TDD systems (a.k.a ping-pong systems) at low frequencies that introduces a rather complex cross-talk noise in neighbouring copper pairs in the same cable. One highly relevant example is an ISDN variant called TCM-ISDN (TCM – Time Compressed Mode)
20 that is used primarily in Japan. Such TDD system operates in such a way that the signalling up-stream (from the premises to the central office) and downstream (from the central office to the premises) is divided in different time slots, i.e. all the systems in the same cable is time synchronised.

The cross-talk noise from the TDD system introduced in neighbouring
25 copper pairs will be time variant according to the direction of transmission of the TDD system, i.e. the TDD causes cyclo-stationary cross-talk noise in neighbouring pairs. In certain time periods there will be NEXT (Near End Cross-Talk) and in the other time periods there will be FEXT (Far End Cross-Talk). From a channel capacity point of view, the NEXT is far more damaging than the FEXT since the
30 power spectral density of NEXT is stronger than the power spectral density of FEXT.

Systems that uses higher band width might however be installed in the same cable and overlap the spectrum of the TDD cross-talk noise, e.g. VDSL (Very high bit-rate Digital Subscriber Lines) systems or ADSL (Asymmetric Digital Subscriber
35 Lines). In this case, the lower part of the spectrum will be affected by this cyclo-stationary cross-talk noise. A VDSL system uses frequencies up to about 10 MHz, while the TDM-ISDN perhaps affects the frequencies up to about 2 MHz.

The optimum performance will be achieved when the new installed system is synchronised with the TDD system in such a way that only FEXT is introduced

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One possibility to optimise VDSL according to the TCM-ISDN is to design VDSL as a TDD system with the same time synchronisation as TCM-ISDN, i.e. only transmit VDSL downstream when TCM-ISDN transmits down stream and vice versa. One problem doing so is that the period time for TDM-ISDN is 400 Hz which causes a system delay, or system latency, that is too high than specified for VDSL and can in most cases not be accepted.

20 Summary of the invention

25 In accordance with the invention, the wide band transmission system operates with frequency divided duplex. The wide band is divided in at least two bands, such that the lower band is at least partly overlapping the time divided duplex system. The lower and the higher band are transmitting in opposite directions. The transmission direction of the frequency bands is switched so that the
30 lower band of the wide band transmission system always transmits in the same direction as the time divided duplex system.

Brief description of the drawings

The invention will be described below in detail with reference to the attached drawing, of which the only figure is a signal frequency diagram relating to an arrangement in accordance with the invention.

Detailed description of preferred embodiments

For ease of reference we herewith give a list of the abbreviations used throughout the specification:

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TDD	Time Division Duplex
FDD	Frequency Division Duplex
TCM	Time Compressed Mode
NEXT	Near End Cross-Talk
FEXT	Far End Cross-Talk
VDSL	Very high bit-rate Digital Subscriber Line
ADSL	Asymmetric Digital Subscriber Line

The present invention describes how the effects of cyclo-stationary cross-talk noise from a narrow band TDD system can be mitigated by letting the wide band transmission system use an FDD system where the direction of transmission in two frequency bands can switch transmission direction simultaneously synchronised to the noise. The invention assumes that the cyclo-stationary cross-talk noise is concentrated to lower frequencies, and further that the FDD system uses a larger signal bandwidth that overlaps the narrower TDD signal bandwidth that is located at lower frequencies.

15 This invention describes a way to avoid NEXT from a narrow band TDD system into an FDD system by simultaneously switching transmission direction in two frequency bands synchronously to the TDD systems.

With reference to Figure 1, let us assume that we divide the FDD spectrum in two frequency bands, A and B, where A is the lower frequency band and B the higher frequency band. Figure 1 shows a wide band FDD system with two signalling bands A and B and cross-talk noise, NEXT and FEXT, from a narrow band TDD system. The TDD system has less signal bandwidth than the FDD system and operates in the lower part of the spectrum. The FDD system spectrally overlaps the TDD cross-talk noise. Since the TDD systems cause cross-talk, NEXT and FEXT, in the lower part of the frequency spectrum, band A in the FDD system suffers more from this than frequency band B that is located in the upper part of the spectrum.

The FDD direction of transmission should optimally be arranged in such a way that the FDD system transmit downstream in band A and upstream in band B when the TDD system transmit downstream. In the same way the FDD system should transmit upstream in A and downstream in B when the TDD systems transmits upstream. The FDD wide band transmission system is associated with a switching means adapted to switch the transmission direction in the frequency

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bands. The switch of transmission direction for both bands can be triggered by a synchronisation provided by the TDD system equipment. The FDD system can switch transmission direction in the two frequency bands synchronously to the cyclo-stationary cross-talk noise from a TDD system operating in the same cable (network). The switching of transmission direction in the frequency bands should be arranged so that the lower band of the FDD system always transmits in the same direction as the TDD system and the higher frequency band hence transmit in the opposite direction to the TDD system.

The invention is not limited to an FDD system with only two bands. There might exist more frequency bands at upper part of the spectrum that actually do not need to be switched. The invention requires, however, that the switching of direction is done in pairs and that the transmission direction of one band is always the opposite of the other. Each frequency band of the FDD system can be used for either upstream or for downstream transmission.

One benefit with this invention is that it does not cause long latency in the FDD system if the TDD system switches direction with a low periodicity. The simultaneous switching of transmission directions in the two frequency bands does not add extra latency to the wide band transmission signal. With this arrangement the near end cross-talk from the TDD system into the wide band transmission system is avoided and the far end cross-talk from the TDD system will be the limiting noise source.